1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	E. Mannel

4. WBS Element Code	5. WBS Element Title
1.07.01	Calorimeter Electronics Oversight and Management

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost only, no material. Labor based on subsystem engineer with 10% of time spent on project management.

TECHNICAL SCOPE:

Level 2 Engineer overseeing and managing the design, prototyping and production of EMCal and HCal front end and back end electronics. Responsibilities include budgeting, preparation of reports and presentations.

WORK STATEMENT:

Provide management and oversight of the design, prototyping and production of the electronics for the sPHENIX EMCal and HCal electronics. Specific tasks include:

1. Produce and monitor overall schedule for all aspects of the design, prototyping and production of the sPHENIX EMCal and HCal electronics to make sure that all milestones are met on schedule.
2. Provide overall management of procurement activities and monitoring of expenditures for the sPHENIX EMCal and HCal electronics
3. Work with scientific and engineering staff to produce all technical design documents. Review documentation to make sure that the design will achieve the performance needed to meet the scientific goals of sPHENIX.
4. Participate in project reviews:
    a. Assist with producing review documents.
    b. Make presentations at project reviews when requested.
5. Organize and schedule technical design, prototype performance and production readiness reviews for the sPHENIX EMCal and HCal electronics.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	S. Stoll

4. WBS Element Code	5. WBS Element Title
1.07.02.01	EMCal Sensor Specification

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost for a scientist (25% time) and engineer (50% time) to test, evaluate and write design specification documents. Labor cost for technician (25% time) to help with assembly of test equipment and conducting tests. Material costs for purchasing sample optical sensors for testing and components needed for test fixtures.

TECHNICAL SCOPE:

Scientist and engineer to review and test potential optical sensors and select the sensor that meets the measurement requirements for the EMCal. Write design specification document to be used for the purchase of the optical sensors.

WORK STATEMENT:

This task covers the specification of the optical sensors to be used for the sPHENIX EMCal. Work includes:

1. Write design requirement document for the sPHENIX EMCal optical sensors.
2. Review potential commercial optical sensors that meet the general design requirements of the sPHENIX EMCal
3. Procure sample sensors for detailed evaluation to confirm that they meet the design requirements as defined in the design specification documents.
4. Design and execute tests to evaluate the performance of potential optical sensors for the sPHENIX EMCal.

Deliverables are design specification documents to be used for the purchase of prototype and production optical sensors for the EMCal.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	S. Stoll

4. WBS Element Code	5. WBS Element Title
1.07.02.02	EMCal Sensor Procurement

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor costs are based on an engineer working 10 to 25% of time obtaining quotes, submitting purchase requisitions, monitoring delivery and overseeing testing of prototype and production sensors. Technician time for setting up and testing of prototype (50%) and production (25%) sensors. Student time at 100% for testing of production sensors.

TECHNICAL SCOPE:

Engineer to manage the procurement and testing of optical sensors needed for all prototypes and production of the EMCal. Technician to assist with setting up and testing optical sensors for prototypes and production EMCal detectors. Students to assist in the testing and sorting of production sensors for the EMCal.

WORK STATEMENT:

This task covers the procurement and Q/A testing of all optical sensors for the EMCal:

1. Obtain quotes for EMCal optical sensors for all prototyping stages and production.
2. Submit orders for EMCal optical sensors for all prototyping stages and production.
3. Monitor delivery of EMCal optical sensors.
4. Design test procedures for Q/A acceptance.
5. Test SiPMs for Q/A acceptance and sort production sensors based on performance criteria.

Deliverables are optical sensors for prototype EMCal electronics testing and production EMCal electronics.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	S. Stoll

4. WBS Element Code	5. WBS Element Title
1.07.02.03	HCal Sensor Specification

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost for a scientist (25% time) and engineer (50% time) to test, evaluate and write design specification documents. Labor cost for technician (25% time) to help with assembly of test equipment and conducting tests. Material costs for purchasing sample optical sensors for testing and components needed for test fixtures.

TECHNICAL SCOPE:

Scientist and engineer to review and test potential optical sensors and select the sensor that meets the measurement requirements for the HCal. Based on the evaluation testing, write design specification document to be used for the purchase of the optical sensors.

WORK STATEMENT:

This task covers the specification of the optical sensors to be used for the sPHENIX HCal. Work includes:

1. Write design requirement document for the sPHENIX HCal optical sensors.
2. Review potential commercial optical sensors that meet the general design requirements of the sPHENIX HCal
3. Procure sample sensors for detailed evaluation to confirm that they meet the design requirements as defined in the design specification documents.
4. Design and execute tests to evaluate the performance of potential optical sensors for the sPHENIX HCal.

Deliverables are design specification documents to be used for the purchase of prototype and production optical sensors for the HCal.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	S. Stoll

4. WBS Element Code	5. WBS Element Title
1.07.02.04	HCal Sensor Procurement

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor costs are based on an engineer working 10 to 25% of time obtaining quotes, submitting purchase requisitions, monitoring delivery and overseeing testing of prototype and production sensors. Technician time for setting up and testing of prototype (50%) and production (25%) sensors. Student time at 100% for testing of production sensors.

TECHNICAL SCOPE:

Engineer to manage the procurement and testing of optical sensors needed for all prototypes and production of the HCal. Technician to assist with setting up and testing optical sensors for prototypes and production HCal detectors. Students to assist in the testing and sorting of production sensors for the HCal.

WORK STATEMENT:

This task covers the procurement and Q/A testing of all optical sensors for the HCal:

1. Obtain quotes for HCal optical sensors for all prototyping stages and production.
2. Submit orders for HCal optical sensors for all prototyping stages and production.
3. Monitor delivery of HCal optical sensors.
4. Design test procedures for Q/A acceptance.
5. Test SiPMs for Q/A acceptance and sort production sensors based on performance criteria.

Deliverables are optical sensors for prototype HCal electronics testing and production HCal electronics.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	S. Boose

4. WBS Element Code	5. WBS Element Title
1.07.03.01	EMCal On Detector Electronics Design

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Cost is for labor only. Scientist at 25%, engineer at 10% to 25%, and designer at 50%

TECHNICAL SCOPE:

Scientist, engineers and designers to specify, design and layout the on-detector prototype and production electronics for the EMCal detector. Work covers the specification, design, and layout of the preamplifier, EMCal mother board, EMCal control board, power systems, and signal and power cables

WORK STATEMENT:

This WBS item covers all aspects of the on-detector electronics design and layout for all prototypes and production systems for the EMCal. Specific tasks include:

1. Writing overall design documents and updating design documents based on testing of prototype systems.
2. Designing ground plan for EMCal electronics.
3. Design of preamplifier circuits for the EMCal
4. Design and layout of EMCal mother boards and EMCal control boards
5. Selection of components taking into consideration radiation tolerances and magnetic field requirements.
6. Review design documents at each stage prior to submission for fabrication.
7. Design of power systems, including working on cable routing plan in conjunction with mechanical design of the EMCal and support structure.
8. Provide estimate of heat load and cooling requirements for detector design
9. Review performance of prototype stages, write design specification changes documents, and update design documents after each prototype stages.
10. Provide necessary documents and drawings, and participate in reviews as required.

Deliverables are:

1. Design documents (schematics, layout files, component specifications, and bill of materials required for all prototype stages and production stages of the EMCal electronics development including power systems and cables.
2. Estimated heat and power loads for EMCal electronics
3. Grounding plan for EMCal detector
4. Cable plan for EMCal detector.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	S. Boose

4. WBS Element Code	5. WBS Element Title
1.07.03.02.01	EMCal On Detector Electronic: Prototype v1

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Cost is for labor and material: Scientist at 25% for testing and writing design change specifications, engineer at 10% to 50% to oversee material procurement, assembly and testing, and technician at 10% to 25% to procure all components, assemble and assist with testing of the EMCal prototype v1.

TECHNICAL SCOPE:

Scientist, engineers and technicians to oversee the procurement of parts, assembly and testing of the EMCal prototype v1. Results of the testing will provide input to design changes for the EMCal frontend prototype v2 electronics.

WORK STATEMENT:

The WBS item covers the production and testing of the EMCal Prototype v1 electronics. Production covers the procurement of components necessary for 6 64-channel motherboards, including daughter cards, power supplies and test fixtures. Testing is done on the bench with optical sensors illuminated with light sources. Tests include, but are not limited to, testing the dynamic range, cross talk, signal integrity, performance of the temperature compensation circuit, and power distribution. Results of the tests are used to write a design change document to be reviewed and used to implement design changes in the EMCal Prototype v2 electronics. Measurements of the power and heat loads of the circuits will be made and used to make preliminary estimates of the cooling requirements.

Deliverables include a full EMCal prototype v1, prototype test result documents and design specification changes for EMCal prototype v2.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	S. Boose

4. WBS Element Code	5. WBS Element Title
1.07.03.02.02	EMCal On Detector Electronic: Prototype v2

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Cost is for labor and material: Scientist at 25% for testing and writing design change specifications, engineer at 10% to 50% to oversee material procurement, assembly and testing, and technician at 10% to 25% to procure all components, assemble and assist with testing of the EMCal prototype v2.

TECHNICAL SCOPE:

Scientist, engineers and technicians to oversee the procurement of parts, assembly and testing of the EMCal prototype v2. Results of the testing will provide input to design changes for the EMCal frontend preproduction prototype electronics.

WORK STATEMENT:

The WBS item covers the production and testing of the EMCal Prototype v2 electronics. Production covers the procurement of components necessary for six 64-channel motherboards, including daughter cards, power supplies, cables and test fixtures. Testing is done on the bench with optical sensors illuminated with light sources and includes testing with the Digitize Prototype v2 if available. Tests include, but are not limited to, testing the dynamic range, cross talk, signal integrity, performance of temperature compensation circuit, and power distribution. Results of the tests are used to write a design change document to be reviewed and used to implement design changes in the EMCal Production Prototype electronics. Measurements of the power and heat loads of the circuits will be made and used to update the cooling requirements.

Deliverables include a full EMCal prototype v2, prototype test result documents and design specification changes for EMCal preproduction prototype.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	S. Boose

4. WBS Element Code	5. WBS Element Title
1.07.03.02.03	EMCal On Detector Electronics: Preproduction Prototype

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Cost is for labor and material: Scientist at 25% for testing and writing design change specifications, engineer at 10% to 50% to oversee material procurement, assembly and testing, and technician at 10% to 25% to procure all components, assemble and assist with testing of the EMCal preproduction prototype.

TECHNICAL SCOPE:

Scientist, engineers and technicians to oversee the procurement of parts, assembly and testing of the EMCal preproduction prototype. Results of the testing will provide input to design changes for the EMCal frontend production electronics.

WORK STATEMENT:

The WBS item covers the production and testing of the EMCal Pre-Production Prototype electronics. Prior to fabrication an electrical safety review will be conducted to insure that the pre-production design meets the BNL CA-D electrical safety requirements. Any changes required to meet BNL CA-D safety requirements will be incorporated into the preproduction design before fabrication and assembly. Fabrication and assembly covers the procurement of components necessary for six 64-channel motherboards, including daughter cards, power supplies and cables. Testing is full chain test of the on-detector electronics mounts on the pre-production EMCal prototype and readout with the preproduction digitizer electronics at a test beam. Tests include, but are not limited to: testing dynamic range, cross talk, signal integrity, performance of the temperature compensation circuit, power distribution, hardware mounting, and cable routing. Results of the tests are used to write a design change document to be reviewed and used to implement design changes in the EMCal production electronics. Measurements of the power and heat loads of the circuits will be made and used to finalize the cooling requirements.

Deliverables include a full EMCal preproduction prototype, prototype test result documents,

design specification changes for EMCal production electronics, and final heat and power load estimates.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	S. Boose

4. WBS Element Code	5. WBS Element Title
1.07.03.03	EMCal On Detector Electronics Production

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor costs are for: Engineer to oversee and manage procurement of all components (10%), fabrication of all electronics boards (10%), and assembling and testing of all electronics (25%). Technician to procure of all components (10%), oversee fabrication of all electronics boards (10%), and oversee and assist with the final assembly and testing of all electronics (25%). Students to assist with final assembly and testing (100%). Material costs are for all components needed for the full production of EMCal electronics. Component costs are based on costs of similar boards. Board assembly is assumed to be done by a commercial assembly company. Total costs for the total number of boards required for the final detector and do not include spares. A 10% yield loss is assumed.

TECHNICAL SCOPE:

This WBS items covers the production of the front end electronics required for the full EMCal. Major components include the EMCal mother boards with preamps, daughter boards with temperature compensation circuitry, interface boards, controller boards, power system (low voltage and bias) and all power and signal cables required for the final design.

WORK STATEMENT:

This WBS item covers the full procurement, fabrication, assembly, and testing of the all frontend electronics required for the sPHENIX EMCal. Prior to procurement a final readiness review of the final design will be performed to insure that the production design meets the design requirements for the sPHENIX EMCal detector. Procurement covers the process of obtaining quotes for all components needed for production, placing purchase requisitions, tracking orders, and Q/A of delivered components. Fabrication covers obtaining quotes for assembly of major boards, placing purchase requisitions for board assembly, tracking assembly, working with assembly house to address any assembly issues that might arise, and Q/A of delivered boards. The assembly stages includes the assembly of final modules for testing and delivery for

installation into the EMCal.

The deliverables are full tested frontend electronics, power supplies and cables for installation into the sPHENIX EMCal.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	S. Boose

4. WBS Element Code	5. WBS Element Title
1.07.03.04	HCal On Detector Electronics Design

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Cost is for labor only. Scientist at 25% to 50%, engineer at 10% to 50%, and designer at 50%

TECHNICAL SCOPE:

Scientist, engineers and designers to specify, design and layout the on-detector prototypes (v1, v2 and preproduction) and production electronics for the HCal detector. Work covers the specification, design, and layout of the HCal preamplifier board, HCal controller board, power systems, and signal and power cables

WORK STATEMENT:

This WBS item covers all aspects of the on-detector electronics design and layout for all prototypes and production systems for the HCal. Specific tasks include:

1. Writing overall design documents and updating design documents based on testing of prototype systems.
2. Designing ground plan for HCal electronics.
3. Design of preamplifier circuits for the HCal
4. Design and layout of HCal control boards
5. Selection of components taking into consideration radiation tolerances and magnetic field requirements.
6. Review design documents at each stage prior to submission for fabrication.
7. Design of power systems, including working on cable routing plan in conjunction with mechanical design of the HCal and support structure.
8. Provide preliminary estimate of heat load and cooling requirements for detector design
9. Review performance of prototype stages, write design specification changes documents, and update design documents after each prototype stages.
10. Provide necessary documents and drawings, and participate in reviews as required.

Deliverables are:

1. Design documents (schematics, layout files, component specifications, and bill of materials required for all prototype stages and production stages of the HCal electronics development including power systems and cables.
2. Estimated heat and power loads for HCal electronics
3. Grounding plan for HCal detector
4. Cable plan for HCal detector.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	S. Boose

4. WBS Element Code	5. WBS Element Title
1.07.03.05.01	HCal On Detector Electronic: Prototype v1

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Cost is for labor and material: Scientist at 25% for testing and write design change specifications, engineer at 10% to 50% to oversee material procurement, assembly and testing, and technician at 10% to 25% to procure all components, assemble and assist with testing of the HCal prototype v1.

TECHNICAL SCOPE:

Scientist, engineers and technicians to oversee the procurement of parts, assembly and testing of the HCal prototype v1. Results of the testing will provide input to design changes for the HCal prototype v2 frontend electronics.

WORK STATEMENT:

The WBS item covers the production and testing of the HCal Prototype v1 electronics. Production covers the procurement of components necessary for a 32 of HCal Preamplifiers (16 inner HCal, 16 Outer HCal), including controller boards, power supplies and test fixtures. Testing is done on the bench with optical sensors illuminated with light sources. Tests include, but are not limited to, testing dynamic range, cross talk, signal integrity, performance of temperature compensation, and power distribution. Results of the tests are used to write a design change document to be reviewed and used to implement design changes in the HCal Prototype v2 electronics. Measurements of the power and heat loads of the circuits will be made and used to make preliminary estimates of the cooling requirements.

Deliverables include a full HCal prototype v1, prototype test result documents and design specification changes for HCal prototype v2.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	1/21/14	S. Boose

4. WBS Element Code	5. WBS Element Title
1.07.03.05.02	HCal On Detector Electronic: Prototype v2

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Cost is for labor and material: Scientist at 25% for testing and write design change specifications, engineer at 10% to 50% to oversee material procurement, assembly and testing, and technician at 10% to 25% to procure all components, assemble and assist with testing of the HCal prototype v2.

TECHNICAL SCOPE:

Scientist, engineers and technicians to oversee the procurement of parts, assembly and testing of the HCal prototype v2. Results of the testing will provide input to design changes for the HCal frontend preproduction prototype electronics.

WORK STATEMENT:

The WBS item covers the production and testing of the HCal Prototype v2 electronics. Production covers the procurement of components necessary for a 32 of HCal Preamplifiers (16 inner HCal, 16 Outer HCal), including controller boards, power supplies and test fixtures. Testing is done on the bench with optical sensors illuminated with light sources. Tests include, but are not limited to, testing dynamic range, cross talk, signal integrity, performance of temperature compensation and power distribution. Results of the tests are used to write a design change document to be reviewed and used to implement design changes in the HCal Pre-Prototype electronics. Measurements of the power and heat loads of the circuits will be made and used to update the cooling requirements.

Deliverables include a full HCal prototype v2, prototype test result documents and design specification changes for HCal preproduction prototype

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	S. Boose

4. WBS Element Code	5. WBS Element Title
1.07.03.05.03	HCal On Detector Electronics: Preproduction Prototype

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Cost is for labor and material: Scientist at 25% for testing and write design change specifications, engineer at 10% to 50% to oversee material procurement, assembly and testing, and technician at 10% to 25% to procure all components, assemble and assist with testing of the HCal preproduction prototype.

TECHNICAL SCOPE:

Scientist, engineers and technicians to oversee the procurement of parts, assembly and testing of the HCal preproduction prototype. Results of the testing will provide input to design changes for the HCal frontend production electronics.

WORK STATEMENT:

The WBS item covers the production and testing of the HCal Pre-Production Prototype electronics. Prior to fabrication an electrical safety review will be conducted to insure that the pre-production design meets the BNL CA-D electrical safety requirements. Any changes required to meet BNL CA-D safety requirements will be incorporated into the preproduction design before fabrication and assembly. Fabrication and assembly covers the procurement of components necessary for a 32 HCal channels (16 inner HCal and 16 outer HCal), including daughter card, power supplies and test fixtures. Testing is full chain test of the on-detector electronics mounts on the pre-production HCal prototype and readout with the preproduction digitizer electronics at a test beam. Tests include, but are not limited to, testing: dynamic range, cross talk, signal integrity, performance of the temperature compensation circuit and power distribution, hardware mounting and cable routing. Results of the tests are used to write a design change document to be reviewed and used to implement design changes in the HCal production electronics. Measurements of the power and heat loads of the circuits will be made and used to finalize the cooling requirements.

Deliverables include a full HCal preproduction prototype, prototype test result documents, design specification changes for HCal production electronics, and final heat and power load estimates.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	S. Boose

4. WBS Element Code	5. WBS Element Title
1.07.03.06	HCal On Detector Electronics Production

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor costs are for: Engineer to oversee and manage procurement of all components (10%), fabrication of all electronics boards (10%), and assembling and testing of all electronics (25%). Technician to procure of all components (10%), oversee fabrication of all electronics boards (10%), and oversee and assist with the final assembly and testing of all electronics (25%). Students to assist with final assembly and testing (100%). Material costs are for all components needed for the full production of HCal electronics. Component costs are based on costs of similar boards. Board assembly is assumed to be done by a commercial assembly company. Total costs for the total number of boards required for the final detector and do not include spares. A 10% yield loss is assumed.

TECHNICAL SCOPE:

This WBS items covers the production for all front end electronics required for the full HCal. Major components include the HCal preamps, HCal interface boards, HCal controller boards, power system (low voltage and bias) and all power and signal cables required for the final design.

WORK STATEMENT:

This WBS item covers the full procurement, fabrication, assembly, and testing of the all frontend electronics required for the sPHENIX HCal. Prior to procurement a final readiness review of the final design will be performed to insure that the production design meets the design requirements for the sPHENIX HCal detector. Procurement covers the process of obtaining quotes for all components needed for production, placing purchase requisitions, tracking orders, and Q/A of delivered components. Fabrication covers obtaining quotes for assembly of major boards, placing purchase requisitions for board assembly, tracking assembly, working with assembly house to address any assembly issues that might arise, and Q/A of delivered boards. The assembly stage includes the assembly of final modules for testing and delivery for

installation into the HCal.

The deliverables are fully tested frontend electronics, power supplies and cables for installation into the sPHENIX HCal.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	C. Chi

4. WBS Element Code	5. WBS Element Title
1.07.04.01	Calorimeter Digitizer Design

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost only: Scientist to write design specifications and review prototype test results (10%). Engineer to assist with design specification (50%), select components and generate schematic design files to meet the design specifications (50%) and review final layout files (10%). Designer to layout electronics boards based schematics and design specifications (50%).

TECHNICAL SCOPE:

This WBS item covers the writing of design specification, component selection, schematic design, PCB board layout out, and FPGA code development for all components need for the digitizers for the HCal and EMCal. Major modules are: XMIT module, Clock Master, Digitizer Boards, crates and backplanes, and power systems. Work covers all prototypes (v1, v2, preproduction) and production boards.

WORK STATEMENT:

This WBS item covers all design stages of the sPHENIX calorimeter digitizer system. Design work includes: writing and updating design specifications for the prototype and production stages, producing complete schematics and layout files for all boards comprising the digitizer system, specifying components, producing bill of material documents for component procurement, specifying and designing power systems and cables.

Deliverables are all design documents (specifications, schematics, bill of materials) needed for prototype and production fabrication, FPGA code, crate and power system design specifications, and cable specification for power and Digitizer-to-DCM signals.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	C. Chi

4. WBS Element Code	5. WBS Element Title
1.07.04.02.01	Calorimeter Digitizer Prototype v1

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost for: Scientist to oversee assembly of; assist with testing of prototype v1, and write design change specifications for prototype v2 (25%). Engineer to assemble, test and write design change specifications (25%). Technician to oversee procurement of components, assembly of all PCB boards (10%), and assist with final assembly and testing of prototype v1 electronics (25%). A commercial vendor will do PCB board assembly.

TECHNICAL SCOPE:

This WBS item covers the procurement of all components, assembly, testing and writing design change specifications for 384 channel digitizer prototype v1. Test results will be used for writing design change specifications for the prototype v2 digitizer electronics

WORK STATEMENT:

This WBS items covers the assembly of a 384-channel digitizer prototype v1. Assembly work includes: the procurement of all components (obtaining quotes, placing purchase requisitions, tracking orders, and Q/A of delivered components), fabrication of all boards, and assembly of crate and power systems for the v1 prototype. Bench testing includes testing of frontend digitizers, FPGA code for buffering and transmission of triggered data to DCM system and testing of controller board. Heat and power loads are also measured to estimate cooling requirements for the digitizer racks. Design specification changes are written based on bench tests.

Deliverables include: Fully functional 384 channel prototype v1, design change specifications for prototype v2, and estimated power and heat loads for the digitizer system.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	C. Chi

4. WBS Element Code	5. WBS Element Title
1.07.04.02.02	Calorimeter Digitizer Prototype v2

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost for: Scientist to oversee assembly of; assist with testing of prototype v2, and write design change specifications for preproduction prototype (25%). Engineer to assemble, test and write design change specifications (25%). Technician to oversee procurement of components, assembly of all PCB boards (10%), and assist with final assembly and testing of prototype v2 electronics (25%). A commercial vendor will do PCB board assembly.

TECHNICAL SCOPE:

This WBS item covers the procurement of all components, assembly, testing of a 384-channel digitizer prototype v2. Test results will be used for writing design change specifications for the preproduction prototype digitizer electronics

WORK STATEMENT:

This WBS items covers the assembly of a 384-channel digitizer prototype v2. Assembly work includes: the procurement of all components (obtaining quotes, placing purchase requisitions, tracking orders, and Q/A of delivered components), fabrication of all boards, and assembly of crate and power systems for the v2 prototype. Bench testing includes testing of frontend digitizers, FPGA code for buffering and transmission of triggered data to DCM system and testing of controller board. Heat and power loads are also measured to estimate cooling requirements for the digitizer racks. Design specification changes are written based on bench tests.

Deliverables include: Fully functional 384 channel prototype v2, design change specifications for preproduction prototype, and estimated power and heat loads for the digitizer system.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX	3/17/2015	C. Chi

4. WBS Element Code	5. WBS Element Title
1.07.04.02.03	Calorimeter Digitizer Preproduction Prototype

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost for: Scientist to oversee assembly of; assist with testing of preproduction prototype, and write design change specifications for production (25%). Engineer to assemble, test and write design change specifications (25%). Technician to oversee procurement of components, assembly of all PCB boards (10%), and assist with final assembly and testing of the preproduction prototype electronics (25%). A commercial vendor will do PCB board assembly.

TECHNICAL SCOPE:

This WBS item covers the procurement of all components, assembly, and testing change for a 384-channel digitizer preproduction prototype. Test results will be used for writing design change specifications for the production digitizer electronics

WORK STATEMENT:

This WBS items covers the assembly of a 384-channel digitizer preproduction prototype. Assembly work includes: the procurement of all components (obtaining quotes, placing purchase requisitions, tracking orders, and Q/A of delivered components), fabrication of all boards, and assembly of crate and power systems for the preproduction prototype. The testing is to be done as part of a full system chain test including preproduction EMCal and HCal detectors, preproduction EMCal and HCal frontend electronics and DCM readout. Testing includes testing of frontend digitizers, FPGA code for buffering and transmission of triggered data to DCM system and testing of controller board. Heat and power loads are also measured to determine cooling requirements for the digitizer racks. Design specification changes are written based on chain tests.

Deliverables include: Fully functional 384 channel preproduction prototype, design change specifications for production prototype, and final power and heat loads for the digitizer system.

1. Project Title:	2. Date:	3: Person Responsible
SPHENIX		C. Chi

4. WBS Element Code	5. WBS Element Title
1.07.04.03	Calorimeter Digitizer Production

6. Index Line Number:	7. Revision Number and Authorization:	8: Rev. Date

9. Approved Changes

9. Element Task Description

COST CONTENT:

Labor cost: Scientist to review final design specifications (50%) and test results of production electronics (25%). Engineer to oversee and manage the procurement of all components, PCB board fabrication and final assembly of production digitizer system for the EMCal and HCal. Designer to assist with final design review and modifications for production (25%). Technician for procurement of components and detailed oversight of board fabrication (10%) and work on final assembly of production electronics (25%). Material cost include: the cost for 27392 channels of digitizers (64 channels per board), 28 Controller boards, 28 XMIT boards, 28 crates and associated power supplies. Production costs assume that commercial vendor is used for all PCB board fabrication. Project engineers and technicians do final system assembly and testing. Component cost includes a 10% loss due to yield. No spare modules are included the cost.

TECHNICAL SCOPE:

This WBS item includes the procurement of all components, final assembly and testing of the production electronics for the EMCal and HCal. There are a total of 384 64-channel digitizer boards for the EMCal located in 24 crates. Each crate has 1 controller board and 1 XMIT board. There are a total of 44 64-channel digitizer boards for the HCal located in 4 crates, with each crate having a controller board and XMIT board.

WORK STATEMENT:

This WBS item covers the full production of the digitizer system for the sPHENIX calorimeters. Prior to start of production, a readiness review is to be conducted to insure that the system meets the design requirements for the sPHENIX calorimeter digitizer system. The procurement process includes obtaining quotes for all components necessary for the digitizer system, placing purchase requisitions for components, tracking deliver of components and Q/A of delivered components. The fabrication and assembly stage covers the assembly of all PC boards required for the digitizer system, assembly of crates and power supplies and installation of system boards

into crates for testing. The testing stage covers the testing 24 fully assembled crates for the sPHENIX EMCal and 4 crates for the sPHENIX HCal detectors

Deliverables: 28 crates of fully tested digitizers, associated power supplies and cables for installation into the sPHENIX detector.